

CTDD's 0.5 tonne/h pressurized spouted bed gasifier. Gasifier process performance, operability, emissions and solids handling issues have been established for a range of operating conditions and results are presented. Operating performance target criteria for the gasifier as a component of the air blown gasification cycle have been met with resultant fuel gas calorific values of $>4.0 \text{ MJ/N m}^3$, fuel conversion efficiency of 78% and sulfur retention efficiency with sorbent addition of $>90\%$. Also presented are the results from a further phase of study targeted at increased waste feed rates and differing fuel characteristics.

Solar energy

99/00553 Ageing of solar booster reflector materials

Nostell, P. *et al.* *Solar Energy Materials and Solar Cells*, 1998, 54, (1-4), 235-246.

This paper discusses the experiment whereby anodized aluminium lacquered with polyvinylidene fluoride, anodized aluminium, vacuum evaporated aluminium foil and stainless steel have been aged up to 7 years. It was found that anodized aluminium is not long-term durable, while the others show only slow deterioration. Stainless steel, however, has very low solar reflectance to make it useful. A promising material is lacquered aluminium, which is durable but tends to become scattering after ageing. Another promising reflector material is vacuum evaporated aluminium foil, which after more than 6 years of ageing is still highly reflective and very specular. The optical characterization should ideally be performed with scatterometers and integrating spheres with this acceptance angle. The characterization should, furthermore, be carried out at an incidence angle of 45° for booster reflectors.

99/00554 Application of probability models to Malaysian sunshine data

Yusof Sulaiman, M. *et al.* *International Journal of Energy Research*, 1998, 22, (9), 833-842.

A 10-year Malaysian sunshine data of four stations were fitted to three models, namely the Bendt, Hollands and Ruget and Saunier models. Distribution parameters of the models were determined from the values of the observed mean of the sunshine data. The Kolmogorov-Smirnov test was applied to determine the goodness of fit. It was found that the Saunier model was suitable for the Petaling Jaya and Subang stations while the Hollands and Huget model well suited the Bayan Lepas and Kota Bharu stations. The Bendt model did not give a good fit for all stations. It was also found that for the months that have the same observed mean but different observed standard deviations the distribution models were able to fit well only if the estimated standard deviations were close in value to the observed standard deviations.

99/00555 Carbon nanotubes: the solar approach

Laplace, D. *et al.* *Carbon*, 1998, 36, (5/6), 685-688.

Using the same experimental set-up as for the solar production of fullerenes, we can also produce carbon nanotubes by direct vaporization of a mixture of powdered carbon and catalyst. The structure of the nanotubes is strongly dependent on the experimental conditions and we can obtain either multi-walled nanotubes or ropes of single-walled nanotubes.

99/00556 Development of a new self-powered electrochromic device for light modulation without external power supply

Bechinger, C. and Gregg, B. A. *Solar Energy Materials and Solar Cells*, 1998, 54, (1-4), 405-410.

Electrochromic window coatings are still too expensive to be applied in buildings on a large scale despite considerable improvements within the last few decades. Wiring costs have to be added which may exceed the fabrication expenses of the electrochromic window. Self-powered electrochromic windows have been considered, where a semi-transparent photovoltaic cell provides the power to activate an electrochromic system deposited on top of the solar cell. The writers recently came up with a much simpler idea where power generation and electrochromic properties are combined rather than just added as in the case of the PVEC cell. The whole device now is obtained by the deposition of only three layers and is highly transparent in the bleached state. Exposing it to sunlight and completing an external circuit the device can be coloured within a few minutes, reducing the transmission by about 40%.

99/00557 Economic evaluation of the solar thermal co-production of zinc and synthesis gas

Steinfeld, A. and Spiewak, I. *Energy Conversion and Management*, 1998, 39, (15), 1513-1518.

By using concentrated solar energy for co-producing zinc and synthesis gas from ZnO and natural gas upgrades the calorific value of the initial reactants by 39% and has the potential of reducing CO₂ emissions by up to 78% when compared to the traditional carbothermic reduction of ZnO. An economic assessment for a 50,000 mt/yr chemical plant, 30 to 51 MW solar input, indicates that the cost of solar thermal production of zinc ranges

between 89-133 \$/mt (excluding the cost of ZnO feed and credit for pollution abatement) and, thus, might be competitive with conventional fossil fuel based processes at current fuel prices.

99/00558 Economics of solar air pre-heating in south Indian tea factories: a case study

Palaniappan, C. and Subramanian, S. V. *Solar Energy*, 1998, 63, (1), 31-37. As it requires both thermal and electrical energy tea processing is an energy intensive operation. In the past coal or firewood burning has been used. Over the last four years, roof integrated solar air heating systems have been introduced in some of the tea factories of south India, as a partial energy source. This paper aims to present the economical analysis of one such system: a 212 m² collector area system that has been in operation for 2.75 years. The system has reduced specific fuel consumption for tea production from 0.932 to 0.71 kg/kg dmt, fuel savings of approximately 25%. The economic analysis considered the annual investment cost and return cost and included concessions offered by the Government. It shows a payback period of from two to four years, depending upon whether the company is profit making or non-profit making.

99/00559 Efficiency bound of a solar-driven stirling heat engine system

Chen, J. *et al.* *International Journal of Energy Research*, 1998, 22, (9), 805-812.

A solar-driven Stirling engine is modelled as a combined system which consists of a solar collector and a Stirling engine. The performance of the system is investigated, based on the linearized heat loss model of the solar collector and the irreversible cycle model of the Stirling engine affected by finite-rate heat transfer and regenerative losses. The maximum efficiency of the system and the optimal operating temperature of the solar collector are determined. Moreover, it is pointed out that the investigation method in the present paper is valid for other heat loss models of the solar collector as well, and the results obtained are also valid for a solar-driven Ericsson engine system using an ideal gas as its engine work substance.

99/00560 Fuzzy algorithm for estimation of solar irradiation from sunshine duration

Sen, Z. *Solar Energy*, 1998, 63, (1), 39-49.

A model involving the relationship between solar irradiation and sunshine duration can best be derived by methods that explicitly take vagueness into account. In this paper, the theory of fuzzy sets is employed to represent solar irradiation and sunshine duration relations as a set of fuzzy rules. A fuzzy logic algorithm has been devised for estimating the solar irradiation from sunshine duration measurements. The main advantage of fuzzy models is their ability to describe the knowledge in a descriptive human-like manner in the form of simple rules using linguistic variables only. In this manner the classical Angstrom or any other type of regression equations can be replaced by a set of fuzzy rule bases.

99/00561 Hydrogen formation from biomass using solar energy

Rustamov, V. R. *et al.* *Int. J. Hydrogen Energy*, 1998, 23, (8), 649-652.

By using solar energy the process of thermocatalytic reforming of cellulose has been studied. It has been established that the process of conversion proceeds through depolymerization stages of cellulose with formation of hexoses including following the dehydration of three molecules water, first and secondary conversion. It is shown that carbohydrate of compound [6C(H₂O)₃] undergoes thermocatalytic conversion by water steam. In addition, the possibility of obtaining synthesis-gas [H₂+CO] with temperatures of 700-750° on the catalyst Pt/Al₂O₃ is shown. Also studied has been the dependence of gas formation on temperature and degree of dilution by water steam.

99/00562 Materials for solar energy conversion: an overview

Granqvist, C. G. and Wittwer, V. *Solar Energy Materials and Solar Cells*, 1998, 54, (1-4), 39-48.

This paper introduces the radiative properties of our natural surroundings and demonstrate how the characteristic features of thermal emission, atmospheric absorption, solar irradiation, and sensitivity of the human eye and of plant photosynthesis lead naturally to a set of solar energy materials with well-defined wavelength- and angular-dependent absorptance, emittance, reflectance, and transmittance. Specific discussions are given of anti-reflection through microstructuring and of overheating protection through thermotropism.

99/00563 Non-axisymmetric reflectors concentrating radiation from an asymmetric heliostat field onto a circular absorber

Spirkl, W. *et al.* *Solar Energy*, 1998, 63, (1), 23-30.

Where a rotationally symmetric field of heliostats surrounds the tower, in a solar tower plant, an axisymmetric secondary concentrator such as a compound parabolic concentrator (CPC) or a tailored concentrator or a cone is the obvious choice. However, for locations at higher latitudes the reflecting area of the heliostats may be used more efficiently if the field of heliostats is located opposite to the sun as seen from the tower. Then the field is asymmetric with regard to the tower. In the case of an asymmetric field, an axisymmetric concentrator necessarily has a concentration significantly lower than the upper limit. Furthermore, the area on the